DOCUMENT RESUME

ED 379 158 SE 055 775

AUTHOR Dujari, Anuradha Sodhani
TITLE The Effect of Two Components of the Dimensions of Learning Model on the Science Achievement of Underprepared College Science Students.
PUB DATE [Dec 94]
NOTE 34p.
PUB TYPE Reports - Research/Technical (143) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; Black Colleges; Classroom Research; *College Preparation; *College Science; *College Students; Effect Size; Higher Education; High Schools; Science Education; Scientific Concepts; *Undergraduate Study
IDENTIFIERS *Science Achievement

ABSTRACT

Learning science is complex and difficult for many students and their understanding of science concepts and processes may be inaccurate or lacking. In an effort to improve the science achievement of underprepared students enrolled in a general science course, an integrative instructional model, "Dimensions of Learning" was used. Since acquiring and integrating knowledge (Dimension 2) and extending and refining knowledge (Dimension 3) are very important, these components of the model were emphasized. Selected strategies of these two components were used to teach an interdisciplinary science unit on the chemical basis of life for a 4-week period. The control group received the same science content instruction as the experimental group. The study, conducted at an historically black university, investigated whether the two components of the Dimensions of Learning improve the science achievement of the underprepared college students (n=27). No statistically significant difference in the science achievement of these students was found at 0.05 level, however an effect size of 0.69 SD indicated that students benefited from the selected strategies of the learning model. The results are encouraging since these strategies could easily be used for improving undergraduate science instruction. Contains the test, a student data card, and 41 references. (Author/ZWH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 379 158

9E

The Effect of Two Components of the Dimensions of Learning Model on the Science Achievement of Underprepared College Science Students

Anuradha Sodhani Dujari

Delaware State University

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

ANURADHA S. DUJARI

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)"

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- This document has been reproduced as received from the person or organization originating it.
- Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

SE055775

BEST COPY AVAILABLE

Table of Contents

Page

Abstract....iii

Acknowledgement....iv

I. Introduction....1

Statement of the Problem....3

Description of Dimensions of Learning model....6

II. Literature Review....10

III. Research Methods

Research Design....11

Sampling Procedures....11

Experimental Treatment & Procedures....12

Measures....15

IV. Results....16

V. Summary and Discussion....19

References....20

Appendix....

A. Key Concepts of the Unit....25

B. Test....26

C. Student Data Card....29

ACKNOWLEDGEMENT

The author is indebted to Dr. William J. McIntosh for his direction of the project and criticism of the test. The author expresses thanks and appreciation to Dr. B. Patricia Patterson for reviewing and critiquing the test.

Abstract

Learning Science is complex and difficult for many students and their understanding of science concepts and processes may be inaccurate or lacking. In an effort to improve the science achievement of underprepared students enrolled in a general science course, an integrative instructional model 'Dimensions of Learning' was used. Since acquiring and integrating knowledge (Dimension 2) and extending and refining knowledge (Dimension 3) are very important, these components of the model were emphasized. Selected strategies of these two components were used to teach an interdisciplinary science unit on the chemical basis of life for a four week period. A quasi-experimental, nonequivalent, control group design was used. The control group received the same science content instruction as the experimental group. The study, conducted at an historically black university, investigated whether the two components of the Dimensions of Learning improve the science achievement of the underprepared college students (n=27). No statistically significant difference in the science achievement of these students was found at .05 level, however, an effect size of 0.69 SD indicated that students benefited from the selected strategies of the learning model. The results are encouraging since these strategies could be easily used for improving undergraduate science instruction.

The Effect of Two Components of the Dimensions of Learning Model on the Science Achievement of Underprepared College Science Students

Introduction

Scientific knowledge and an understanding of science processes are important for attaining a baccalaureate degree, particularly for science majors. Support services and remedial classes are intended to help curb the attrition rate by helping students overcome deficiencies in these scientific skills.

Many college freshmen take remedial courses in mathematics, writing, and reading. Open admission colleges and public colleges in general offer more remedial courses than private colleges. For example, in 1983-84, as many as 27% of freshmen were enrolled in remedial mathematics courses at public colleges, as compared to 15% at private colleges (Wright, 1985). The percentages for remedial writing and reading were respectively 22% and 18% at public colleges versus 12% and 9% for the private colleges. Moreover, 23% of public colleges offered remedial courses in academic subjects such as high school level science or social studies as opposed to 17% for private colleges (Wright, 1985).

There is a call for national reform in science education from various quarters. For example, the American Association for Advancement in Science (AAAS), through its Project 2061, is working on its reform initiative to improve education for 'all' students (AAAS,

1989). The National Science Teachers' Association (NSTA) has published its 'content core' for curriculum development which specifies what the students should know in different science subjects at the completion of certain grade levels in school (Aldridge, 1992). Reform in science education requires that changes in all facets of teaching, use of learning materials, and testing be compatible (Rutherford & Ahlgren, 1990).

This call for reform in science education is not limited to grades K-12 (National Science Education Standards, 1993), but there is concern at the college level as well (Tobias, 1992; Tobias & Tomizuka, 1992). The Society of College Science Teachers has issued a position statement urging that introductory college science courses contribute to scientific literacy and critical thinking, as well as, provide a conceptual base for upper level courses in sciences (Halyard, 1993). A systemic reform at the college level will be better achieved if the college science educators become aware of precollege science reforms and integrate research based teaching strategies (McIntosh, 1994).

Delaware State University (DSU) is an historically black university located in Dover, Delaware. Upon admission to the school, those students who score below a local median of the Sequential Test of Educational Progress (STEP) Science Series II, are required to take a general science course. Completion of this course with a "Satisfactory" grade is a prerequisite for the underprepared science students who wish to pursue various technology related majors such as chemistry, biology,

mathematics, nursing, psychology, and agriculture. These underprepared science students are enrolled in the General Science course within three semesters of their college entry to strengthen their science skills so that they can benefit from future science courses. Waivers for this institutional requirement are given to those students who for some reason have not taken the general science course in their first three semesters but have achieved favorable grades in their science major.

Statement of the Problem

Learning science is a complex and difficult process of conceptual change. If student understanding rather than rote learning is tested, students don't perform as well. A conceptual change in learning, requires students to get rid of their previously held misconceptions, and to reshape their ideas or beliefs about scientific phenomena (Anderson, Roth, Hollon & Blakeslee, 1987; Roth & Anderson, 1987). For conceptual changes to occur in learning, students are required to go beyond memorization of facts and definitions. Anderson, Sheldon and DuBay (1990) found that students in college nonscience majors' biology course had certain misconceptions which persisted despite completing 1.9 years of previous biology coursework. Previous instruction in biology or chemistry did not seem to affect their performance on pretest nor did it help them to master the conceptions during the course.

This is a situation that this author has encountered. The students who have had science courses before entering college, when

asked questions to demonstrate their understanding cannot do so. With traditional instruction they are not learning material outside of recall. There is little indication of transfer or extension of knowledge. Therefore an instructional approach that will let the students do some critical or higher level of thinking is needed.

There is a difference in the way meaningfully and rotely learned materials are learned and retained. As Ausubel, Novak, and Hanesian (1978) state, "One important implication of the discrete and isolated incorporation of rote learning tasks within cognitive structure is that, quite unlike the situation in meaningful learning, anchorage to established ideational systems is not achieved. Hence, since the human mind is not efficiently designed for long-term, verbatim storage of arbitrary associations, the retention span for rote learnings is relatively brief" (p. 146).

Behaviorist tradition dominated the learning process prior to reemergence of cognitive psychology. Since the 1950s, there has been a tremendous growth in cognitive psychology which is dominated by the information processing approach (Anderson, 1985). Marzano (1992a) has stated, "Cognitive psychologists view learning as a highly interactive process of constructing personal meaning from the information available in a learning situation and then integrating that information with what we already know to create new knowledge" (p. 5). Connecting information is important if reforms in education are to make any lasting changes in student learning (Brooks & Brooks, 1993;

Rutherford & Ahlgren, 1990).

Various instructional models or programs are based on cognition and learning. One of the latest models of instruction is Dimensions of Learning (DOL). The DOL model is derived from the theory and research base of Dimensions of Thinking . The five dimensions of thinking are "metacognition, critical and creative thinking, thinking processes, core thinking skills, and the relationship of content-area knowledge to thinking" (Marzano et al., 1988, p. 4). These form the theoretical basis from which the DOL model evolved (Marzano, 1992a).

The DOL model provides a practical framework that can be used for all grade levels and content area (Marzano, 1992a). The DOL model provides a teacher's manual, with a full repertoire of the teaching strategies that can be used by a teacher in planning instruction, reorganizing curriculum, and assessment. With its wide variety of strategies for each dimension, the teacher's manual provides a practical tool from which teaching strategies relevant to a unit can be chosen (Marzano et al., 1992b)

In essence, the DOL model is an integrative framework for instructional planning because it incorporates a number of instructional strategies from other popular programs. The premise of this model is that all teacher actions cue student thinking, eliciting certain behaviors (Marzano & Pickering, 1991). With the emphasis on systemic reform, if research based teaching strategies are used students

might learn more. Marzano (1992a) states, "The belief underlying the DOL model is that both content knowledge and thinking and reasoning processes need to be taught if we want students to become proficient learners" (p. 32).

The five components of the DOL model are (1) Developing positive attitudes and perceptions about learning, (2) Acquiring and integrating knowledge, (3) Extending and refining knowledge, (4) Using knowledge meaningfully, and (5) Developing good habits of mind.

Dimension 1. Positive attitudes and perceptions are categorized as those related to the learning climate and classroom tasks (Marzano, 1992a). A learner's mental climate is influenced by a sense of acceptance and a sense of comfort and order in classroom. If these factors are overtly fostered in the classroom through planning, in such a way that they are part of the instructional fabric, then these attitudes and perceptions are reinforced in the students (Marzano, 1992b). Perceiving classroom tasks as important is crucial for proficient learning (Marzano, 1992a).

Dimension 2. Acquiring and integrating knowledge is important in any given subject. Reasoning and thinking processes need to be taught along with the content. Although thinking skills and content could be taught separately, transfer does not necessarily occur when these components are taught separately (Perkins, 1987). At the most basic level there are two types of knowledge, declarative and procedural. Anderson (1985) has stated, "Declarative knowledge refers

to knowledge about facts and things; procedural knowledge refers to knowledge about how to perform various cognitive activities" (p. 198). To learn declarative knowledge is to construct meaning (Marzano, 1992a).

Constructing meaning, organizing, and storing information are three phases of learning declarative knowledge. Learners have to be aided in acquiring this knowledge. Learning procedural knowledge requires constructing models, shaping, and internalizing. Teachers have to plan instruction to maximize these opportunities (Marzano, 1992b).

Dimension 3. Extending and refining knowledge requires that students engage in analytic activities that extend and refine knowledge. There are sets of activities such as comparing, classifying, inducing, deducing, analyzing errors, constructing support, abstracting, and analyzing perspective that help in thinking critically (Ennis, 1987). As Marzano (1992a) states, "..... once information is acquired and stored in long-term memory, it can be changed--and in the most effective learning situations, it is changed" (p. 67).

Dimension 4. Using knowledge meaningfully is necessary for many tasks such as decision making, investigation, experimental inquiry, problem solving, and invention (Marzano, 1992a). Learning can be facilitated by planning for the meaningful use of knowledge. By providing opportunities for the above mentioned tasks students are encouraged to explore personal interests and direct their own learning

(Marzano, 1992a).

Dimension 5. Productive habits of the mind are mental habits such as self-regulation, critical thinking and creative thinking. Critical thinking is necessary for higher order learning (Paul, 1990). Creative thinking encompasses domain-relevant skills, creativity-relevant skills, and task motivation (Amabile, 1983).

Can the science achievement of underprepared science students be improved by using two specific dimensions of an instructional model called Dimensions of Learning (Marzano, 1992a) as opposed to conventional method of teaching?

The two specific dimensions (2 & 3) for use in this study are selected because as Marzano (1992a) states, "A fundamental goal of schooling is for students to learn whatever is deemed important in a given subject--in other words, to acquire and integrate knowledge" (p. 31). But learning goes beyond just acquiring and integrating knowledge. Learning is more effective when the information that is received is continually modified and refined (Marzano, 1992a).

This study sought to obtain research knowledge concerning improvement of student learning. By using two specific components of the DOL model, namely, acquiring and integrating knowledge (Dimension 2), and extending and refining knowledge (Dimension 3), the researcher anticipated that the students' performance will improve when they are taught an interdisciplinary science unit on 'Chemical Basis of Life'. With an emphasis on systemic reform in teaching of

introductory level science courses, resulting in improved academic achievement, this pilot study should add empirical data to the literature. Following are the definitions of the terms used in this study:

Academically underprepared science college students: Those students who scored below the local median on the Sequential Test of Educational Progress (STEP) Science Series II, upon admission to DSU.

Science achievement: The scores obtained on the tests on the content matter of the interdisciplinary science unit, Chemical Basis of Life.

II. Literature Review

Literature review supports the notion that teaching thinking skills is important (Beyer, 1987; Nickerson, 1987; Beyer, 1988). Thinking skills could contribute to betterment in students' learning (Amuah, 1990), and that thinking skills will develop fully as a result of instruction and practice.

The DOL model of instruction advocates teaching of thinking skills along with the content. The two specific components of the DOL utilize various strategies which help in the thinking involved in acquiring and integrating knowledge (Dimension 2) and in extending and refining knowledge (Dimension 3). Some of the selected strategies are advance organizers, concept attainment, graphic organizers, analogies, and extending and refining activities such as comparison, classification, and analysis of errors. A representative sample of the research studies on analogies and metaphors attested to their efficacy as instructional tools with certain precautions (Duit,1991; Thiele & Treagust, 1994; Thagard, 1992). Stavy and Tirosh (1993) and Clement (1993) found positive results with the use of analogies whereas Morris (1990) did not. The effects of Advance organizers were ambiguous (Healy, 1989; Willerman & Mac Harg, 1991; 1993, Mize 1989). There is limited empirical research available on graphic organizers (Clarke, 1991). There was paucity of research in the literature on the effects of analytical techniques of extending and refining activities on improvement in science education.

III. Research Method

Research Design

A quasi-experimental nonequivalent control group design was used for this exploratory quantitative research. In this design, intact classes can be assigned to experimental and control groups and a pretest and a posttest are given to both the groups (Campbell & Stanley, 1963). The design is depicted as following:

O X O

O O

In the above diagram, O refers to some kind of test or observation and X refers to a treatment or an experimental variable on a group. The broken line separates the comparison groups.

Sampling procedures

Delaware State University located in Dover, Delaware (DE), is an historically Black university. Located in Mid-Atlantic region, this institution of higher learning originated as a land grant institution. The University has open admission policy. DSU grants Bachelor's degrees in twenty-six disciplines. The graduate program grants Master's degrees in Biology, Chemistry, Physics, Education, Social Work, and Business / Economics.

The total enrollment was 3301 students during the academic year of 1993-94. Sixty-eight percent of the students came from the state of Delaware, thirty percent came from out of state and two percent were from foreign countries. Freshman full time students were 554 males

and 713 females. The ethnic make-up of the freshman class was 62% Black, 32% White and 6% Other, as stated in Delaware State University Fact Book (1993, Fall).

The data for this study were derived from a group of underprepared students taking the General Science course in the Spring of 1994 at DSU. The two sections of the General Science class constitute the sample. The students selected one of the two class sections available depending on day or time of class meeting that was suitable to them. Although not randomly selected, the students are similar or homogenous in their ability level, because these are the students scoring below the local median on the Science Series II, of STEP Test. The two class sections were then randomly assigned to the experimental or the control group by a coin toss. The annual Spring enrollment traditionally has been approximately 30 students. The majority (96%) of the students were African-Americans thereby presenting a group of subjects who were racially homogenous.

The experimental and control groups were compared on the following characteristics such as age, sex, race, high school grade point average (HSGPA), and pretest scores to determine whether they were initially equivalent. t-tests were used to identify the differences.

Experimental Treatment & Procedures

The study was of four weeks duration with eight class sessions of 75 minutes each. The total time spent on testing and instruction was equal for both the groups. Attendance was taken daily. The

experimental variable is the use of strategies of Dimension 2 and Dimension 3, of the Dimensions of Learning model, in teaching an interdisciplinary science unit on the Chemical Basis of Life. The dependent variable is the science achievement as measured by student scores obtained on the science content matter of the unit.

The experimental and control groups were administered a researcher constructed pretest measuring their science concept knowledge of the Chemical Basis of Life unit. Prior to that, they signed consent forms and filled out the student data card (Appendix C). The experimental group was taught the science concept matter using the relevant strategies of two specific components of the DOL model. The control group received the science concept instruction using the traditional lecture method. At the end of four weeks, the groups were administered a posttest which measured their science concept knowledge. All the instruction and scoring was done by the researcher.

The specific strategies used for Dimension 2 were student aid in constructing meaning of the material by using the K-W-L activity. In the K-W-L activity, the students are asked what they know about the material, what they want to know about the material, and what they have learned about the material. Other strategies for constructing meaning for declarative knowledge are analogizing and brainstorming. Advance organizers, which take the form of questions posed to students before they read a section in a textbook or some other activity, were used. In organizing the information learned, descriptive and

concept patterns were modeled for the students. Students were aided in internalizing the information by massed and distributed practice. Massed practice refers to repetition of an activity in one session; whereas the distributed practice takes place over a period of two or three sessions so that the information or process is internalized.

Strategies used for the Dimension 3 were error analysis, classifying, and comparing. To extend and refine knowledge it is essential that students use such activities for knowledge acquired. Error analysis deals with information which might be presented wrong, and asks the students to analyze what is wrong with the information. This activity helps in refining the skills.

Classification is an activity used at all levels to group objects into different categories. In this process, students think of the attributes and characteristics that will make the classification meaningful. The students were introduced to classifying, and the steps involved were described. Students were shown a way to graphically represent the classification process.

Comparison is the process used when one wants to see similarities and differences in objects. The process of comparison was introduced to students and the steps were shown and demonstrated. The process was presented and a comparison matrix was introduced to the students graphically.

Measures

The 20 item test based on the key concepts of an interdisciplinary science unit on Chemical Basis of Life (Appendix A), consists of twelve multiple choice and eight short answer questions (Appendix B). After several revisions, the test was deemed to have content validity by two university professors who teach science education. This measure was used for pre and post test in the study.

To obtain the reliability correlation coefficient, the test was administered to undergraduate students taking an introductory Biology course for nonmajors. A split-half reliability analysis was done on the test. A correlation coefficient was computed and corrected with Spearman-Brown Prophecy Formula (Lang & Heiss, 1987). The reliability correlation coefficient for the test was 0.70, and was considered satisfactory for this study.

Statistical analyses included a paired (pretest- posttest) two-tailed t-test. The t-tests were used to determine whether the two means differ significantly from each other. Calculation of effect size is a measure of the practical significance of the outcome in research where improvement in student learning is being investigated. To compute effect size, a formula is used in which the difference in the means of the two groups (control and experimental) is divided by the standard deviation of the control group (Borg & Gall, 1989).

IV. Results

The control and experimental groups were compared on the variables such as age, sex, race, HSGPA and pretest scores to determine if they were initially equivalent. Race and sex variables were given dummy numerical scores to facilitate quantitative analyses. Female and male were assigned values of 0 and 1, respectively. For race, numerical values of 2 and 3 were given to Blacks and Whites respectively. Table 1 provides a summary of descriptive analysis on Race, Sex, Age, HSGPA and pretest variables. The average age of the students was 19 years. The majority of the students were African Americans. The majority of the sample were women.

Table 1. Summary of Descriptive Analyses on Characteristics Variables

	Factor	Age	Sex	HSGPA	Race	Pretest
Experimental	Mean	19	0.23	2.77	2.07	21.28
	S.D.	1.10	0.43	0.59	0.27	9.24
Control	Mean	19	0.38	2.54	2	18.38
	S.D.	0.80	0.50	0.32	0	8.37

A summary of t-test results on various variables is shown in Table 2. The group means did not differ significantly, thereby indicating that the experimental and control groups were initially equivalent in these characteristics.

Table 2. t-test Analyses of Variables

		n	Mean	SD	deg of freedom	t	p
Age	Experimental	14	19	1.10			
					24	0	1
	Control	13	19	0.81			
Sex	Experimental	13	0.23	0.43			
					22	-0.84	0.40
	Control	13	0.38	0.50			
HSGPA	Experimental	13	2.77	0.16			
					19	1.18	0.25
	Control	11	2.54	0.32			
Race	Experimental	13	2.07	0.27			
					22	1	0.32
	Control	13	2	0			
Pretest	Experiment	14	21.28	9.24			
					25	0.85	0.40
	Control	13	18.38	8.37			

Table 3. Comparison of group means on pretest and posttest

	Factor	Pretest	Posttest	deg of freedom	t	p
Experimental	Mean	20.61	41.46	12	-3.68	0.003*
n=13	S.D.	9.2	18.17			
Control	Mean	18.38	33.38	12	-3.90	0.002*
n=13	S.D.	8.37	11.67			

Results of the comparison of pretest and posttest scores of the experimental and the control groups are shown in table 3. Both the groups gained in scores as $p<.002$ and $p<.003$ are significant values. However, when control posttest and experimental posttest scores were compared, they were not found to be significantly different, as shown in table 4.

Table 4. Comparison of posttest scores of the experimental and control groups

	Mean	S.D.	deg of freedom	t	p
Experimental	41.46	18.17			
			24	1.34	0.19
Control	33.38	11.67			

$$\text{Effect Size} = \frac{\text{Exp. group mean--Control Group mean}}{\text{S.D. of Control group}}$$

Effect size was calculated with the above formula and is 0.69 SD.

V. Summary and Discussion

This pilot study looked at the effect of two specific components of the DOL model (a new integrative instructional model) on the science achievement of academically underprepared science students enrolled at Delaware State University.

Although no statistically significant difference was found in the scores of the experimental and control groups, it is encouraging to note that the DOL strategies used to teach science improved the science scores of the experimental group as evident from the effect size. An improvement in the achievement scores in a short period of time is an indicator of the efficacy of the teaching strategies. An effect size of 0.69 shows a positive change of twenty-five percentiles and therefore confirms the practical significance of the intervention for the underprepared students. Given the small cost of implementation, it is worthwhile to see its effect across wider parameters such as ability levels or subject matter.

The readers are cautioned to the generalizibility of the conclusions due to small sample size and racially homogenous sample. Prior knowledge of participation and researcher as instructor are other considerations limiting the generalizability of the study. This study, however, serves as a base line for subsequent research.

References

Aldridge, B. (1992). Scope, sequence, and coordination of secondary school science: The content core. Washington, DC: The National Science Teachers Association.

Amabile, T. M. (1983). The social psychology of creativity. NY: Springer Verlag

American Association for Advancement of Science (1989). Project 2061: Science for all americans. Washington, DC: American Association for Advancement of Science.

Amuah, I. K., (1989). Physics teaching and the development of thinking skills. Dissertation Abstracts International, 50(12),

Anderson, J. R. (1985). Cognitive psychology and its implications (2nd ed.). New York: W. H. Freeman & Co.

Anderson, C. W., Roth, K. J., Hollon, R., & Blakeslee, T. (1987). Power cell: Teacher's guide to respiration . (Eric Document Reproduction Service No. ED 288 700).

Anderson, C. W., Sheldon, T. H., & DuBay, J. (1990). The effects of instruction on college nonmajors' conceptions of respiration and photosynthesis. Journal of Research in Science Teaching . 27(8), 761-776.

Ausubel, D. P., Novak, J. D. & Hanesian, H. (1978). Educational psychology: A cognitive view (2nd ed.). New York: Holt, Rinehart & Winston.

Beyer, B. K. (1987). Practical strategies for the teaching of thinking .

Boston, MA: Allyn and Bacon.

Beyer, B. K. (1988). Developing a thinking skills program . Boston, MA: Allyn and Bacon.

Borg, W. R., & Gall, M. D. (1989). Educational Research. An introduction (5th ed.). New York: Longman.

Brooks, J. G., & Brooks, M. G.. (1993). In search of understanding: The case for constructivist classrooms. Alexandria, VA: Association for Supervision and Curriculum Development.

Campbell, D. T. & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research. Chicago, IL. Rand McNally.

Clarke, J. H. (1991). Graphic organizers: Frames for teaching patterns of thinking. In A. R. Costa (Ed.), Developing minds: A resource book for teaching thinking (pp 224-231). Alexandria, VA: Association for Supervision and Curriculum Development.

Clement, J. (1993). Using bridging analogies and anchoring intuitions to deal with students' preconceptions in Physics. Journal of Research in Science Teaching. 30(10), 1241-1257.

Delaware State University Fact Book. (1993, Fall). IV, Dover, DE: Office of Institutional Research.

Duit, R. (1991). On the role of analogies and metaphors in learning science. Science Education 75(6), 649-672.

Ennis, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron and R. J. Sternberg (Eds.), Teaching thinking skills: Theory and practice (pp. 9-26). New York: W. H. Freeman.

Halyard, R. A. (1993, Sept / Oct.). Introductory science courses: The SCST position statement. Journal of College Science Teaching, XXIII (1), 29-31.

Healy, V. C. (1989). The effects of advance organizer and prerequisite knowledge passages on the learning and retention of science concepts. Journal of Research in Science Teaching, 26(7), 627-642.

Lang, G. & Heiss, G. D. (1987). A practical guide to research methods (3rd ed.). Lanham, MD: University Press of America, Inc.

Marzano, R. J. (1992a). A different kind of classroom: Teaching with dimensions of learning. Alexandria, VA: Association for Supervision and Curriculum Development.

Marzano, R. J., Brandt, R. S., Hughes, C. S., Jones, B. F., Presseisen, B. Z., Rankin, S. C., & Suhor, C. (1988). Dimensions of thinking: A framework for curriculum and instruction. Alexandria, VA: Association for Supervision and Curriculum Development.

Marzano, R. J. & Pickering, D. J. (1991). Dimensions of learning: An integrative instructional framework. In A. L. Costa (Ed.), Developing minds: A resource book for teaching thinking. (pp94-99). Alexandria, VA: Association for Supervision and Curriculum Development.

Marzano, R. J., Pickering, D. J., Arredondo, D. E., Blackburn, G. J., Brandt, R. S., Moffett, C. A. (1992b). Dimensions of learning teacher's manual. Alexandria, VA: Association for Supervision and Curriculum Development.

McIntosh, W. J. (1994, Mar/Apr.). Systemic reform and the college science educator. Journal of College Science Teaching, XXIII (5), 265-266.

Mize, A. G. P. The use of a graphic advance organizer to improve learning and retention in teaching problem-solving related to the mole concept. Dissertation Abstracts International, 51(06).

Morris, R. A. (1990). The effects of analog-based instruction on the achievement of secondary chemistry students in solving molarity problems. Dissertation Abstracts International 51(05).

National Science Education Standards: An enhanced sampler. (1993, Feb.). A working paper of the National Committee on Science Education Standards and Assessment. Washington, DC: National Research Council.

Nickerson, R. N. Why teach thinking? In J. B. Baron and R. J. Sternberg (Eds.), Teaching thinking Skills: Theory and practice (pp 41-61). New York: W. H. Freeman

Paul, R. W. (1990). Critical thinking: What every person needs to survive in a rapidly changing world. Center for Critical Thinking and Moral Critique. Sonoma State University, Rohnert Park, CA

Perkins, D. N. (1987). Knowledge as design: Teaching thinking through content. In J. B. Baron and R. J. Sternberg (Eds.), Teaching thinking skills: Theory and practice (pp. 62-85). New York: W. H. Freeman.

Roth, K. J. & Anderson, C. W. (1987). The power plant: Teacher's guide to photosynthesis. (Eric Document Reproduction Service No. ED

288 699).

Rutherford, J. F. & Ahlgren, A. (1990). Science for all americans. Washington, DC: American Association for Advancement of Science.

Stavy, R., & Tirosh, D. (1993). When analogy is perceived as such. Journal of Research in Science Teaching. 30(10), 1229-1239.

Thagard, P. (1992). Analogy, explanation, and education. Journal of Research in Science Teaching. 29(6), 537-544.

Thiele, R. B. & Treagust, D. F. (1994). An interpretive examination of high school chemistry teachers' analogical explanations. Journal of Research in Science Teaching. 31(3), 227-241.

Tobias, S. (1992). Revitalizing undergraduate science. Tucson, AZ: Research Corporation.

Tobias, S. & Tomizuka, C. T. (1992). Breaking the science barrier. New York, NY: The College Board.

Willerman, M. & Mac Harg, R. A. (1991). The concept map as an advance organizer. Journal of Research in Science Teaching. 28(8), 705-711.

Wright, D. A. (1985). Many college freshmen take remedial courses. (Report No. NCES-85-211b) Washington, DC: National Center for Educational Statistics. (Eric Document Reproduction Service No. ED 262 742).

The following are the key concepts of Chemical Basis of Life:

1. Atoms are the smallest unit of matter that react with one another to form molecules. (Matter, atom, protons, electrons, neutrons, Ionic bonding, polar covalent bonding, nonpolar covalent bonding, hydrogen bonding).

2. All living beings are composed of inorganic and organic molecules. Examples of organic and inorganic molecules were provided.

3. Some important inorganic molecules are water, acids, bases and salts.

4. Some important organic molecules in a living organism are proteins, carbohydrates, lipids and nucleic acids, formed from small molecules.

Test

Name_____
Date_____
Section_____

Circle the correct response in questions 1-12 (4 points each).

1. The atomic number refers to the
   a. weight of an atom
   b. number of protons in an atom
   c. number of neutrons in an atom
   d. number of electrons in an atom

2. Which is NOT a compound?
   a. salt
   b. water
   c. carbon
   d. glucose

3. The negative subatomic particle is the
   a. neutron
   b. proton
   c. electron
   d. both a and b

4. The nucleus of an atom contains
   a. protons and neutrons
   b. neutrons and electrons
   c. protons and electrons
   d. protons only

5. The bond in table salt (NaCl) is
   a. polar
   b. ionic
   c. covalent
   d. hydrogen

6. The three most common atoms in your body are
   a. oxygen, carbon, and hydrogen
   b. carbon, hydrogen, and nitrogen
   c. carbon, nitrogen, and oxygen
   d. nitrogen, hydrogen, and oxygen

7. How many bonds does carbon usually form with other atoms?
   a. 2
   b. 3
   c. 4
   d. 5

8. Amino acids are the building blocks for
   a. proteins
   b. steroids
   c. lipids
   d. nucleic acids

9. Which is a "building block" of a carbohydrate?
   a. glycerol
   b. simple sugar
   c. monosaccharide
   d. b and c above

10. Plants store their excess carbohydrate in the form of
   a. starch
   b. glycogen
   c. glucose
   d. cellulose

11. Long-term energy storage in a concentrated form is a function of
   a. glucose
   b. lipids
   c. cellulose
   d. proteins

12. Molecules that can function as structural units, hormones, transport molecules, and enzymes are
   a. lipids
   b. carbohydrates
   c. nucleotides
   d. proteins

Concisely and specifically answer the questions 13-20, using only the space provided (4 points each).

13. How are polymers formed?

14. Explain why water is an inorganic compound.

15. Why doesn't aquatic life freeze when the water in which they live freezes?

16. How do animals store carbohydrates?

17. Select a subatomic particle and describe its charge, mass, and location in the atom.

18. List the three classifications of carbohydrates according to their structure.

19. Compare Inorganic compounds with Organic compounds. In your comparison address elements, bonding, molecule size, and where they occur.

20. Describe four biological molecules with regards to their specific function.

Student Data Card

Please provide the following information by writing legibly, and circling the correct responses.

Name: _____ _____
Last First

Date of Birth _____

Sex: Male Female

Year of High School Graduation: _____

High School GPA _____

Race: Black, White, Indian, Asian, Hispanic, Other.

Major in University: _____

Class: Freshman, Sophomore, Junior, Senior.

Are your receiving Financial Aid: Yes NO